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EFFECT OF FORECROPS ON SOIL ENVIRONMENT AND THE PLANT IN RELATION TO THE HEALTH OF THE STRAWBERRY

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A b s t r a c t. This research presents an evaluation of the effect of forecrops (after papilionaceous, root and cereal plants) on the health of the strawberry of the Senga Sengana variety. The diagnostics of diseases were carried out on the basis of symptoms occurring on those parts of the plant above the ground, as well as on the roots, and additionally on the basis of mycological analysis. The results obtained indicate that the main cause of the strawberry dying back and the occurrence of disease symptoms were the species of *Fusarium* genus after root plant fore crops; *Fusarium* spp., *Alternaria* spp., *Botrytis* spp., *Cylidnrocarpon* spp., *Phoma* spp., *Rhizoctonia* spp., and *Verticillum* spp. after papilionaceous plant forecrops and *Fusarium* spp., *Alternaria* spp., *Pythium* spp., *Rhizoctonia* spp. after cereals.

K e y w o r d s: strawberry, forecrops, diseases, pathogens, soil environment.

INTRODUCTION

The growth of plants, their cropping, as well as their health are directly affected by their forecrops. They shape the composition of soil microflora and determine the phytosanitary condition of the soil environment in which various species of pathogenic fungi may occur. Thus, the post-harvest fallow period of the forecrop plants and the soil used for their cultivation may be good carriers of dangerous illnesses to other plants. The presence in the soil of pathogens of such species as *Fusarium, Phytophthora, Pythium, Phoma, Rhizoctonia, Alternaria, Cylindrocarpon, Leptosphaeria, Verticillium* creates a potential risk in strawberry cultivation. They cause diseases of the root system of the strawberry with resultant serious losses to the agricultural economy due to the deficits of plants on plantations [7]. The correct selection of forecrop plants may therefore considerably diminish the development of phytopathogens and interrupt the food chain of a number of fungus diseases.

The objective of this work was to evaluate the health of the strawberry depending on the forecrop, as well as to identify the diseases and their originators.

MATERIALS AND METHODS

The tests were carried out during three consecutive seasons of strawberry vegetation (from the establishment of the crop until its liquidation), in individual farms of the Subcarpatian Province located in the Sokołów Małopolski. The plant material was the Senga Sengana variety of strawberry grown in the following crop-rotation steps:

potato	potato	oats
rye	rye	potato
red clover	potato	rye

In each year of the study, observations were carried out of the health of the above-ground parts of strawberry plants at dates predetermined according to strawberry development phases - in the second part of April and at the beginning of May, in the period of blooming and fruiting, as well as in the second half of the summer while recording the disease symptoms (change of colour, drying of leaves, halted growth and the dying back of the plants). The diagnostics of diseases were carried out on the basis of mycological analysis of roots sampled from studied stations. The method of the isolation of fungi from attacked roots was described in a previous paper [14].

RESULTS OF DISCUSSION

After harvesting, forecrop plants supply to, or leave in, the soil, among others things disease-carrying remains of plants which are a serious menace to subsequent crops.

It has been confirmed by results so far obtained that it was the type of forecrop which made a significant difference in the intensity of the occurrence of phytopathogens in strawberry roots.

After the forecrop of root plants the pathogen species most often isolated from strawberry roots was that of *Fusarium* (Fig. 1). The fungus deserving special attention among those isolated is the *F. oxysporum f.* sp. *fragariae* obtained every year from analysed plant material and considered by many researchers to be the most dangerous pathogen causing root rot and dying back of plants. A strong presence of this pathogen in the attacked tissues of tested strawberry roots leads to the

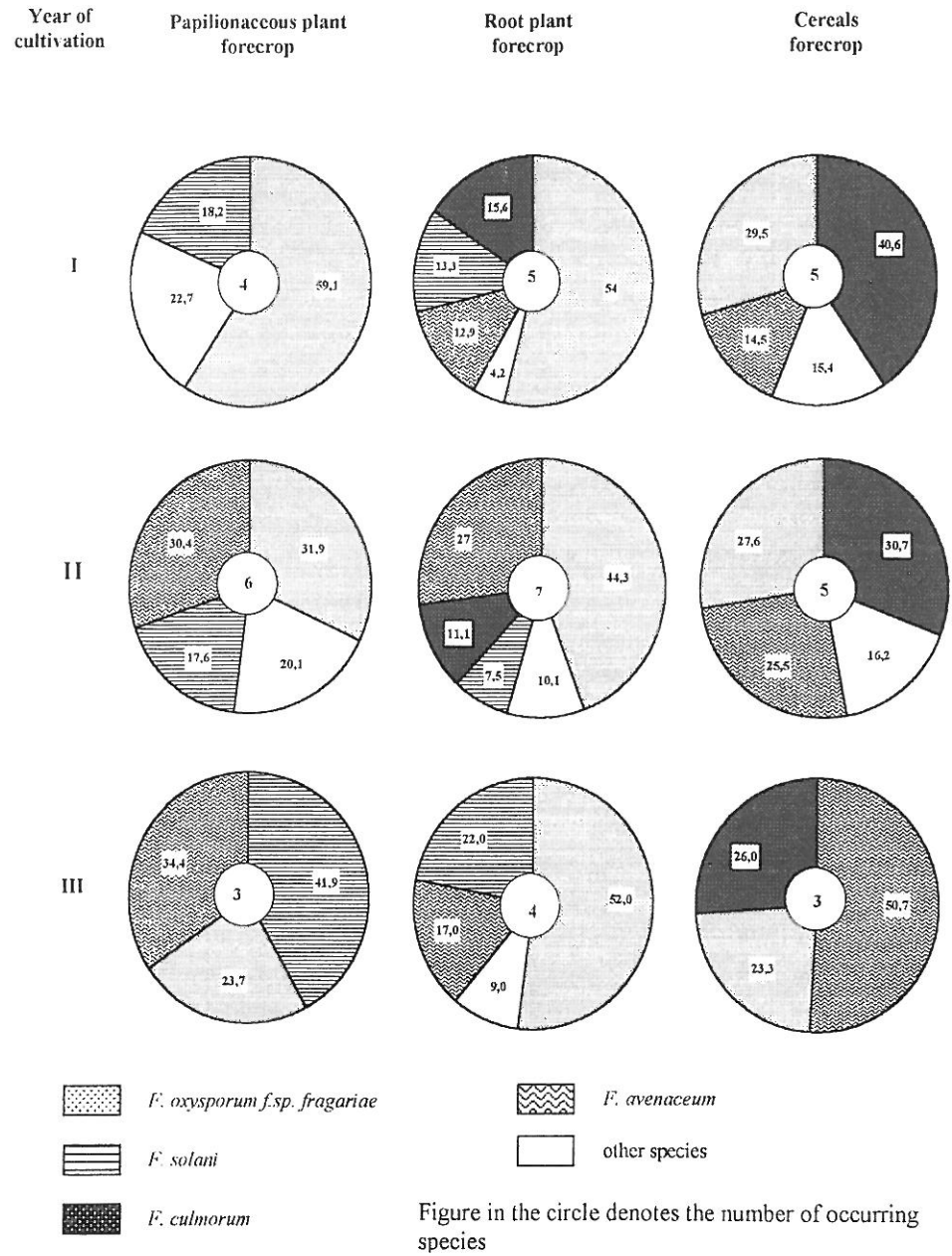

Fig. 1. Percentage share of colonies of *Fusarium* genus species.

assumption that it was the main cause of the pathogen symptoms observed. The characteristic symptoms are: drying of top buds and leaves, halting of growth as well as wilting and the dying back of plants. Two other species representing *Fusarium* genus in larger quantities, i.e. *F. avenaceum* and *F. solani*, were also found in each year of the study but with varying frequency. Both species belong to phytopathogens, however, while the harmful effect of *F. avenaceum* on the strawberry has been confirmed by Kućmierz *et al.* [5], there is no mention in the literature about the pathogenic effects of *F. solani* on this plant. There are a number of reports about the destructive role of this fungus on the root system of other crop plants [2,3,8,12], which may confirm the adaptation of this species to the attacking of strawberry roots.

The main cause fusariosis occurrence on the strawberry crop plantation established after a potato crop were the favourable conditions in the specific crop-rotation object (or step) increasing the population of fungi of *Fusarium* species i.e. cultivation of the potato twice before the strawberry crop is established. The source of the accumulation of the infecting material were the post-harvest fallow periods and the tubers left in the field. The diagnostics of potato diseases, performed at their places of storage and in the field, indicated potato tuber attack by *F. oxysporum* [1,9], as well as *F. avenaceum*, *F. sambucinum* and *F. solani* [18]. The above facts were substantiated by the results obtained on the frequent occurrence of those fungi.

Infections with fungi of the species *Fusarium* were accompanied by other pathogenic species, less numerously isolated from the attacked strawberry roots, such as: *Alternaria alternata, Cylindrocarpon destructans, Rhizoctonia solani* and, rarer occurrences of: *Botrytis cinerea*, *Leptosphaeria coniothyrium*, *Phoma eupyrena*, *Sclerotinia sclerotiorum* and *Verticillium dahliae* (Table 1).

On a plantation established after red clover the number of isolations of *Fusarium* obtained over a three-year test period of affected strawberry roots was 19.5 % lower than that after root plants and 24.0 % higher than that after cereals. The species and quantity contents of *Fusarium* genus varied and only the *F. oxysporum f.* sp. *fragariae* species (Fig. 1) was found each year. The *F. oxysporum f.* sp. *fragariae* species should be considered to be the cause of root system necrosis in the first year of the cultivation and the *F. avenaceum* species - in the second. In the last year of the study the dominating species was *F. solani* which previously occurred in smaller quantities. Besides, in addition to *Fusarium* genus of fungi, the species of *Alternaria alternata*, *Botrytis cinerea*, *Phoma eupyrena*, *Rhizoctonia solani*, were frequently found, as well as, though more rarely, *Verticillium dahliae*

Table 1. Percentage share of pathogenic fungi isolated from strawberry roots in three-year cultivation

Fungi	Forecrop											
	Papilionaceous plants				Root plants				Cereal plants			
	I	II	III	$\bar{x}$	I	II	III	$\bar{x}$	I	II	III	$\bar{x}$
Fusarium spp.	37.0	43.1	54.2	44.7	57.9	62.3	72.4	64.2	43.8	34.2	42.2	40.1
Alternaria alternata	5.7	14.5	4.5	8.2	6.5	6.4	-	4.3	9.0	11.5	15.1	11.9
Botrytis cinerea	7.1	4.2	5.9	5.7	3.3	3.6	-	2.3	7.3	6.9	-	4.7
Cylindrocarpon destructans	13.3	9.0	8.2	10.2	9.8	8.9	14.9	11.2	8.8	7.9	10.2	9.0
Leptosphaeria coniothyrium	3.1	3.9	-	2.3	2.0	1.4	-	1.1	3.9	-	-	1.3
Phoma eupyrena	10.0	12.2	6.2	9.5	2.4	2.0	-	1.5	-	-	-	-
Pythium ultimum	-	-	-	-	-	-	-	-	11.8	13.2	14.4	13.1
Rhizoctonia solani	10.6	8.5	5.1	8.1	11.5	9.6	5.6	8.9	10.7	18.9	17.3	15.6
Sclerotinia sclerotiorum	2.3	1.0	-	1.1	-	3.6	-	1.2	-	1.2	-	0.4
Verticillium dahliae	1.8	2.5	8.2	4.2	2.6	1.6	3.4	2.5	-	0.8	-	0.3
Other	9.1	1.1	7.7	6.0	4.0	0.6	3.7	2.8	4.7	5.4	0.8	3.6

I, II, III - 1st, 2nd and 3rd year of cultivation, respectively.

and *Sclerotinia sclerotiorum*, which indicates a mixed infection (Table 1). The combined pathogenic effect of the fungi mentioned caused a change in leaf colour to yellow-brown, leaf deformation and drying, as well as a steady spreading of rot in the rhizome (main root). The affected plants exhibited arrested growth and died slowly. The occurrence of those symptoms on the above-ground parts of strawberry plants suggest that black root rot may have been their cause.

This diagnosis is supported by previous findings reported by Seemüller (13) and Zinkernagell [19] and other authors [10, according to 16]. Pathogenic factors mentioned by those authors agree well with those obtained from the research while the characteristic pathogenic symptoms of disease on above-ground parts and roots of strawberries described by Seemüller [13] may serve as diagnostic characteristic of the disease.

The occurrence of pathogenic fungi was affected by the forecrop plants - red clover and pre-forecrops, i.e. potato and rye. These plants leave, in the soil, considerable amounts of post-harvest residues which cause a build up of infectious material. Large populations of fungi of *Fusarium, Cylindrocarpon* and *Phoma* genera can be expected directly after the forecrop [2]. Also the occurrence of *Fusarium* of clover tissue may contribute to an increase in the population of *F. oxysporum* in the soil [2]. On the other hand, the forecrops: potato and rye, presumably had a stimulating effect on the development of *Alternaria alternata* and

Rhizoctonia solani, This is confirmed by research indicating the attack of those pathogens on these plants [1,15,17].

Test results obtained indicate that after the forecrop of cereals the proportion of *Alternaria alternata, Botrytis cinerea, Cylindrocarpon destructans, Rhizoctonia solani* and *Pythium ultimum* species (the latter occurring only after cereals) (Table 1) was higher than the proportion of the species of *Fusarium* genus, as well as the highest among those forecrops studied.

Due to their more frequent occurrence, special attention should be given to the species: *Alternaria alternata, Pythium ultimum* and *Rhizoctonia solani* which are considered to be those pathogens which cause root necrosis and the dying back of the strawberry plant. Information provided by Kućmierz *et al.* [5], Nemec [11] and Watanabe *et al.* [16], indicate that each of the above mentioned species attacks the plant in its own peculiar way and causes different and characteristic pathogenic symptoms whereas the combined occurrence of those different species increases their pathogenic effect and causes a more rapid rotting of roots, as has been confirmed by Garrett [4] for the case of *P. ultimum* and *R. solani.*

The diagnosis of strawberry diseases leads to the hypothesis that some part of the plants, similar to the strawberry at its post-papilionaceous stage, has been subjected to mixed or combined infection and some part to *Rhizoctonia spp.* It is confirmed by the observed symptoms: browning of petioles, leaf drying and deformation, arrest of growth, the dying back of affected parts or whole plants and the rotting of roots.

The precondition for the onset fusariosis infection (*F. avenaceum, F. culmorum*) is the rich potential of the infectious material in the soil which presumably came from the forecrop (winter rye). Such conclusion is substantiated by the results of the research by Truszkowska *et al.* [15]. The rye stalk bases are also attacked by *Alternaria alternata* and *Rhizoctonia solani* [15] which explains the build up of infective material in the soil. The potato forecrop also had a stimulating effect on the development of the population of those species [1,17], after which probably the *F. oxysporum* species could also occur, as previously reported [1,9]. The results of research by Lange *et al.* [6] indicate a strong attack on rye and oats by *Pythium ultimum* which may prove a strong presence of inoculating material in the soil after the forecrop and after pre-forecrops, as confirmed by frequent isolations of that species from strawberry roots.

On the basis of performed research it was found that the composition of phytopatogen species differed significantly in a characteristic way for each strawberry cultivation station.

The qualitative and quantitative differentiation of pathogenic fungi was influenced by the forecrops which affected both the soil environment and the plant.

CONCLUSIONS

1. The main cause of the dying back of strawberry plants and the occurrence of pathogenic symptoms on their above-ground parts and roots were the following fungi: *Fusarium* spp. after root plant forecrops; *Fusarium* spp., as well as *Alternaria alternata, Botrytis cinerea, Cylidnrocarpon destructus, Phoma eupyrena, Rhizoctonia solani,* and *Verticillum dahliae* after papilionaceous plant fore crops; *Fusarium* spp., *Alternaria alternata, Pythium ultimum, Rhizoctonia solani* - after cereals.

2. Due to lower proportions of pathogens occupying strawberry roots the forecrop of cereals and that of papilionaceous plants is considered to be superior.

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